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by

Si Gongwang

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ABSTRACT

This article discusses the large scale circulation of the east asian mei-yu fronts as well as their secondary weather dimension or subsynoptic disturbances. It brings out the following points. The east asian mei-yu is a phenomenon produced in the transition belt between Indian monsoon systems and the north Pacific Hadley (or tradewind) systems. Mei-yu fronts are semi-tropical and semi-extratropical weather systems by nature. There is a relationship between the development of mei-yu front torrential rains and previous mei-yu front weather dimension or subsynoptic disturbances

I. FORWARD

The mei-yu area is east asia from the eastern part of China to the southwestern part of Japan. This is " Asia's subtropical humid zone". It is also what Chinese meteorologcal scholars call the east Asia monsoon zone. The east Asia monsoons appear primarily as precipitation belts which move north and retreat south seasonally. During the process of the northward movement of the rainbelts, in the early summer period, they stop over China's Yangtze river valley with onward flows as far as the area of southern Japan. The stop over time is approximately a month more or less. In conjunction with this period, one sees the occurrence of torrential rains. This is the period of the east asian mei-yu. It is the most concentrated period of rainfall during the whole year in this region. The length of the mei-yu period is capable of creating phenomena of drought or waterlogging in the area in question.

The east asian mei-yu is one of the phenomena of the monsoon. In conjunction with this, a great deal of study

has already gone forward on prediction and measurements, diagnosis, and numerical value simulations. This article takes as its foundation the observed facts associated with eastern hemisphere atmospheric circulation, establishing large scale circulation conceptual models for east asian mei-yu phenomena.

The east asian mei-yu fronts are located in the vicinity of $30^{\circ}N$, and they have obvious differences in their natures as compared with polar fronts. The principal meteorological phenomena associated with mei-yu fronts are mei-yu front rainbelts and torrential rains. Mei-yu fronts sometimes strengthen, developing torrential rains. They sometimes weaken even to the point of disappearing. The strengthening and weakening of mei-yu fronts is related to previous mei-yu front subsynoptic disturbances. This article will discuss the disturbances in mei-yu fronts.

II. PLUM RAINS ARE PHENOMENA PRODUCED IN TRANSITION BELTS BETWEEN THE INDIAN MONSOON SYSTEMS AND THE NORTH PACIFIC HADLEY (OR TRADEWIND) SYSTEMS

Lateral average longitudinal ring circulations in the tropics of the whole world are the trade wind or Hadley systems. In the northern hemisphere, the circulations in question, in the vicinity of the equator, are ITCZ zones. Air at lower levels converges upward. In the vicinity of $30^{\circ}N$, these are the secondary tropical high pressure belts. Troposphere air sinks down. The upper part of the troposphere is southwest winds. The bottom part is northeast trade winds.

The east Asia area is subject to a sea-land distribution and large landform type influences. This leads to the destruction of east Asia tropical Hadley systems. This produces summer monsoon systems. Fig.1 is a diagram of

surface flow lines and planar air pressures for July. The north Pacific secondary tropical area is a surface high pressure belt. The northeast trade winds on the south side of the high pressure and the southern hemisphere southeastern trade winds in the vicinity of the equator flow together forming ITCZ. Because of this, 313

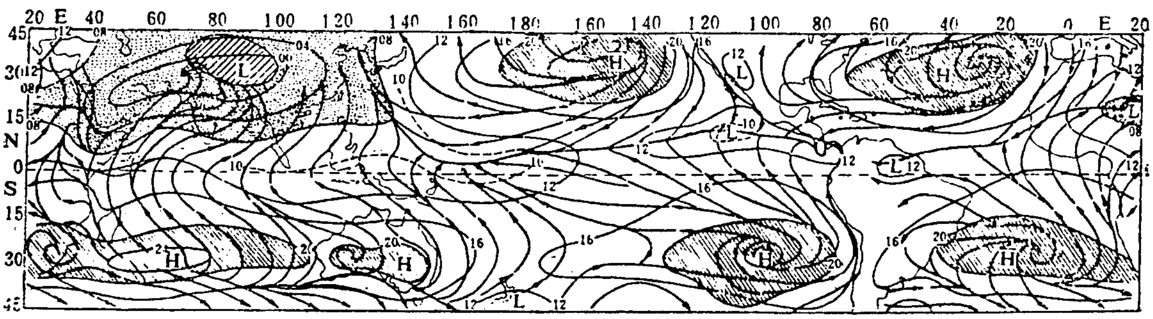

Fig.1 Diagram of Multi-Year Averages for Surface Flow Lines and Oceanic Planar Air Pressures for July(1) (1000hPa must be added to isobar air pressure values. On the diagram, the line shadowed zones are areas of pressure above 1020hPa (H). The dot shaded zones are low pressure areas (L) below 1008 hPa.)

in the North Pacific tropics, there exist classical Hadley circulation systems. The Indian subcontinent circulations in the areas adjacent to the mainland, by contrast, are opposite to the north Pacific. In the secondary tropical

areas, there are low pressure zones. The south sides of the secondary tropical low pressures in question are the northwest monsoons formed after the southeast trade winds of the southern hemisphere cross the equator. When the southwest monsoons approach secondary tropical low pressure, they turn and flow toward the center of the low pressure, forming winds associated with a shear area of turning air. This is nothing other than the Indian monsoon trough associated with the northern part of India. The Indian monsoon trough, in actuality, is the ITCZ associated with the tropical mainland aréa. From the ITCZ average latitudinal positions in January and July given by Riehl(1) (Fig.1.10 of (1)), the July position of the north Pacific ITCZ is south of 10^{O}N. However, the position of the July ITCZ in the vicinity of the Indian subcontinent has arrived north of 20^{O}N. From the longitudinal ring circulations(2) calculated for the Indian monsoon area in July 1958, the whole plateau area to 15^{O}N is all rising movements. The equatorial area south of 10^{O}N is all sinking movements. The upper part of the troposphere is northeast winds. The lower part is soutwest monsoons. This shows up as the monsoon systems of tropical longitudinal ring circulation systems. Monsoon longitudinal ring circulation systems and north Pacific Hadley circulation systems are opposite. The east Asia area is located exactly in the transition zone between the two opposite tropical longitudinal ring circulation systems. It is also the transition zone of the mainland ITCZ (or Indian monsoon trough) and north pacific ITCZ. The discontinuity of mainland and oceanic ITCZ is also capable of being verified from many aspects. Fig.2 is a June-August 850hPa tropical average relative vorticity distribution diagram. In the period of the summer monsoons, the Indian monsoon

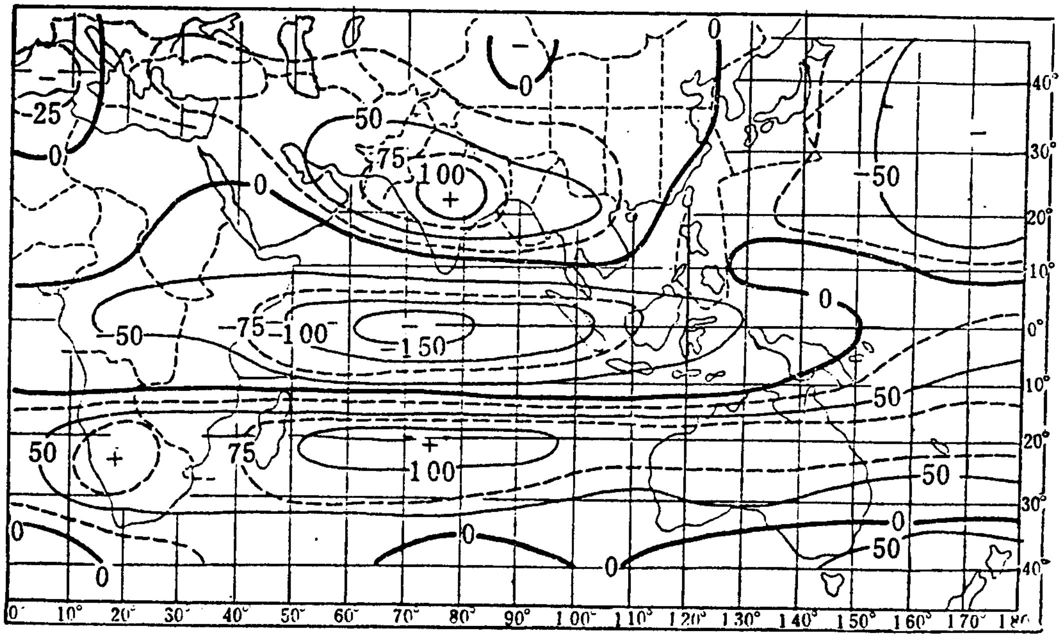

Fig.2 850hPa June-August Tropical Average Relative Vorticity Distribution Diagram(3) (Relative Vorticity Unit: $10^{-7}s^{-1}$)

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and the ITCZ area in the vicinity of the north Pacific equator are each belts of extremely high positive values for relative vorticity. Between them, areas of positive relative vorticity are broken up. In the vicinity of the Phillipines one sees the appearance of negative vorticities. This is one verification of the production of discontinuities between mainland and oceanic ITCZ. Fig.3 is a TIROS-N visible light photograph on 28 June 1979 at 23:38-23:53. On the basis of Krishnamurti and others(4), 26-29 June 1979 was a period of brisk Indian monsoon activity. This time is also the period of the east

asian mei-yu[5]. On the Fig., the Indian monsoon trough cloud belt is located in the vicinity of 20°N. The center of the north Pacific ITCZ cloud belt is at 5-10°N. The two cloud belts occasion discontinuities over the south China peninsula. In this discontinuity area, one sees the appearance of the east asian mei-yu front cloud belt. Fig.1 points out that, in the transition zone between the Indian monsoon trough and the north Pacific ITCZ, the southwest monsoon penetrates deeply into the Chinese mainland. In conjunction with this, the edges of the western Pacific secondary tropical high pressure flow north. When they flow together with westerly belt polar cold air in the secondary or subtropics, this forms the mei-yu (plum rain) fronts.

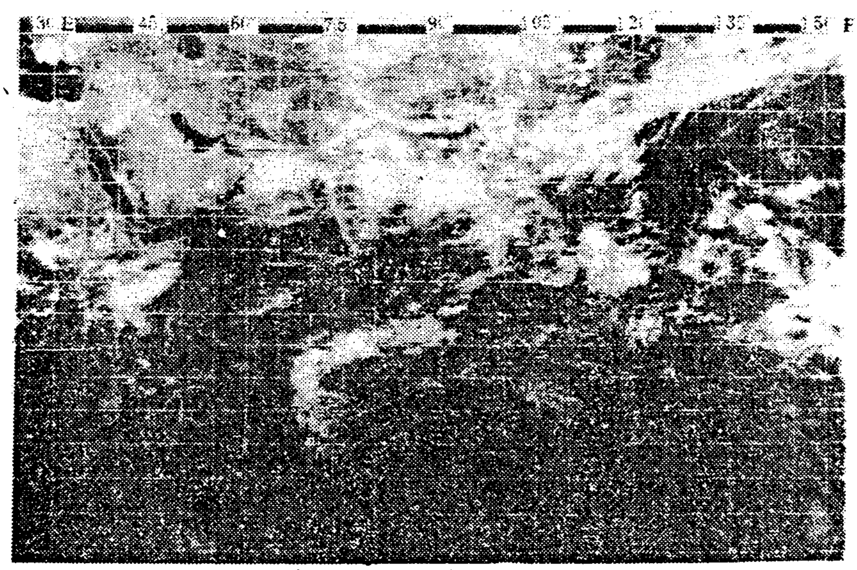

Fig.3 TIROS-N Visible Light Cloud Diagram for 28 June 1979 at 23:38-23:58 GMT

For representation of troposhere flow fields in the vicinity of the mei-yu (plum rain) zone, it is possible to use Fig.4.

Sun Shuqing[6] points out that there is a relationship between the lower atmosphere southwest jet streams associated with the period of the east asian mei-yu and the soutwest Indian monsoon moisture's transmission east. Wang Jizhi and Li Maicun[7] also point out that, in the vicinity of 110^{O}E, there is a branch of trans-equatorial air flow coming from the southern hemisphere. This is related to the south China low atmosphere jet stream. In conjunction with this, it also has effects on both the torrential rains in the pre-flood period in south China and the torrential rains of the Yangtze-Huai river valleys. The works discussed above also demonstrate that the formation of the east asian mei-yu is directly related to the southwest Indian monsoon or the trans-equatorial air flow coming from the southern hemisphere at 110^{O}E. Due to the fact that the east asian mei-yu is a phenomenon related to the southwest Indian monsoon, it is, then, not difficult to understand the mutual relationships between the onset of the southwest Indian monsoon and east Asia's "plums enter". Early in the 1950's, Tao Shiyan and others[8] pointed out the match up in dates between these two. Ye Duzheng[9]also pointed out that they are all phenomena associated with the period of sudden change or mutation when atmospheric circulations change from winter formations to summer formations. The mutual relationships between the onset of the Indian soutwest monsoon and the east asian period of "plums enter" can be described as follows. Following the advance of the southwest monsoon toward the Indian mainland--approximately a week more or less--the monsoon arrives in the northern part of India. This is the phenomenon of the onset of the soutwest Indian monsoon. India's climate enters the rainy

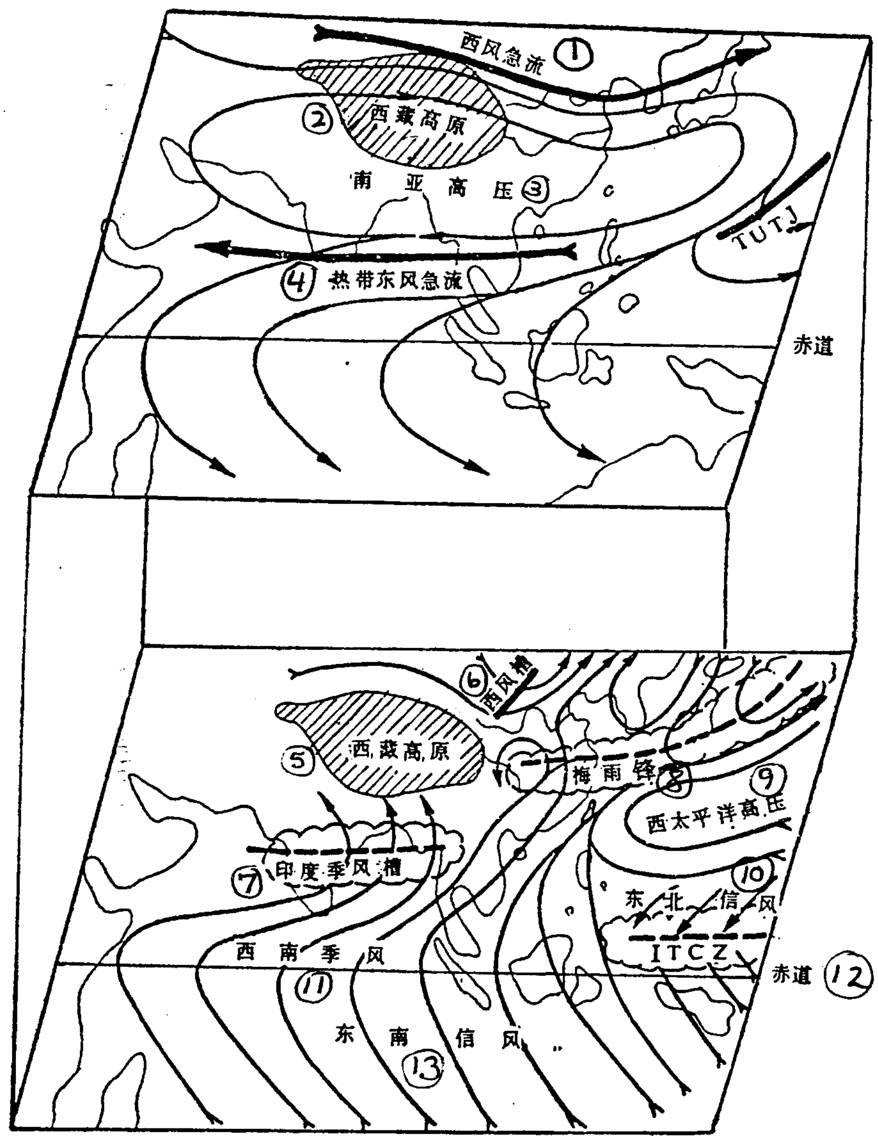

Fig.4 Atmosphere Circulation Forms Associated with East Asian Mei-Yu Areas (TUTT Is Tropical Upper Troposphere Trough) (1) West Wind Jet Stream (2) Tibet Plateau (3) South Asia High Pressure (4) Tropical East Wind Jet Stream (5) Tibet Plateau (6) West Wind Trough (7) Indian Monsoon Trough (8) Plum Rain Front (9) West Pacific High Pressure (10) Northeast Trade Winds (11) Southwest Monsoon (12) Southeast Trade Winds

season due to the change in seasons. At the same time as this, the southwest monsoon also penetrates deeply into China's eastern part. In conjunction with this, in the vicinity of 30^{o}N, the confluence with northern cold air forms the mei-yu fronts and the east asian "plums enter". We can also imagine that, when the east asian "plums enter" is connected with the trans-equatorial air flow in the vicinity of 110^{o}E, at this time, the east asian "plums enter" dates will then not be consistent with the dates of the onset of the Indian southwest monsoon. This awaits further study.

From Fig.4, it is possible to see that mei-yu front systems are neither tropical systems nor temperate systems. The Indian monsoon trough and the north Pacific ITCZ are purely tropical systems. They are confluence zones associated with tropical air masses. Polar fronts are purely temperate systems. They are confluence areas associated with subtropical air masses and polar cold air masses. Yu-mei fronts are the direct flowing together of tropical air masses and polar cold air masses on the north side of subtropical high pressure. It is limited to systems between tropical systems and temperate systems--systems possessing semi-tropical and semi-temperate natures.

III. LARGE SCALE CHARACTERISTICS AND WEATHER ASSOCIATED WITH MEI-YU FRONTS

Mei-yu fronts are weather scale or subsynoptic systems with semi-tropical and semi-temperate natures. They have obvious differences from polar fronts in their natures.

Ninomiya[10] compared the characteristics of mei-yu fronts and polar fronts. He discovered that mei-yu fronts are a line of relatively stable subtropical frontal systems. The horizontal gradients of positional temperatures on front surfaces are relatively small. However, there are relatively strong corresponding horizontal position temperature gradients. Disturbances on frontal surfaces being large and numerous belongs to middle dimension α cyclones (in Japan they are called intermediate dimension). The atmospheric layer structure of frontal areas is neutral or weakly unstable.

Calculations demonstrate[10] that, in mei-yu front areas, there exist geopotential instabilities formed by differential corresponding position warm level flows in the troposphere. When mei-yu fronts receive the effects of low pressure disturbances, the geopotential instabilities formed by level flow will be released, producing strong precipitation. At the same time, this also causes the mei-yu front areas to form neutral atmospheric layer structures.

The eastern and western sections of mei-yu fronts possess different natures. Fig.5 is a diagram showing troposphere flow fields for mei-yu troughs or shear lines. The western section of mei-yu fronts is positioned on the Chinese mainland. It is a confluence region between tropical air masses and polar variable or denatured air masses. They show obvious shearing of southwest winds and south winds. The horizontal temperature gradient associated with western sections of mei-yu fronts is small. Horizontal wind shears are strong. The eastern sections of mei-yu fronts are located over the southern part of Japan. They are confluence regions associated with tropical air masses on the north side of subtropical high pressure and cold

polar air masses. Ninomiya and others(11), in the results from an analysis of mei-yu front low pressure, point out that tropical air masses are transported north along the western edge of Pacific anti-cyclones. Fig.6 is sounding curves associated with recurrence radar echos and the peripheral survey stations for the period of low pressure 26-27 June, 1972. When survey station 819 and Shipk are located in cyclonic warm zones, the sounding curves show the possession of classical tropical air mass characteristics, that is, in the troposphere, the lower part is an atmospheric layer of geopotential instability. In conjunction with this, there is the possession of relatively high humidity. At survey station 909, on the south side of these two survey stations, the sounding curves show the characteristics for subtropical air masses, that is, besides relatively high humidity in the vicinity of the ground surface, the air of the whole troposphere is all unusually dry. Because of this, it proves that tropical air masses are positioned on the north side of subtropical air masses. Due to the fact that the eastern sections of mei-yu fronts are boundary surfaces between cold polar air masses and tropical air masses, therefore, front areas have relatively large horizontal temperture gradients, possessing a certain baroclinic nature. Front areas, in the vertical direction, incline toward cold centers. Because of this, the eastern sections of mei-yu fronts lean toward having the nature of polar fronts.

Differences in the natures of the eastern and western sections of mei-yu fronts are also reflected in there being differences between dynamic factors forcing upward movements in plum rain (mei-yu) front areas. Using equilibrium equation diagnosis to study, one arrives at (see (12)) the principal motive factors forcing upward movements in the

western sections of mei-yu fronts as being the release of latent heat and low layer frictional shear stresses. However, among the compelling motive factors associated with eastern sections, differential voriticity level flows or advection, temperature advection, lower layer frictional shear stresses, as well as cumulus cloud latent heat of convection, and so on, all possess important effects.

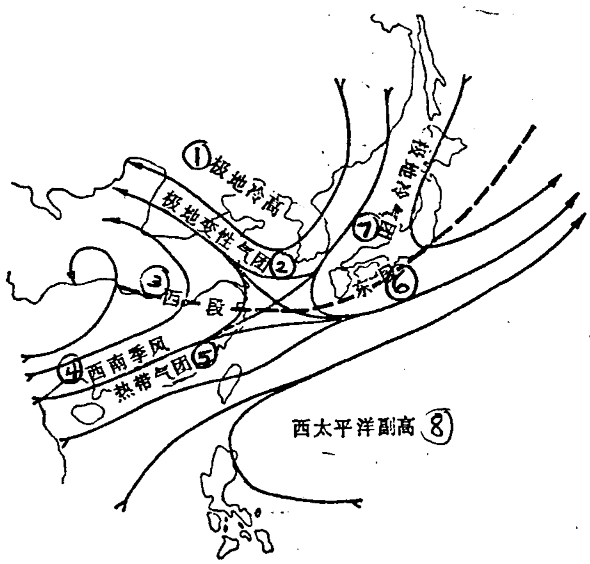

Fig.5 Air Flow Diagram for Mei-Yu Trough or Shear Lines in Lower Part of Troposphere (1) Polar Cold High (2) Polar Variable or Denatured Air Mass (3) Western Section (4) Southwest Monsoon (5) Tropical Air Mass (6) Eastern Section (7) Polar Cold Air Mass (8) West Pacific Secondary High

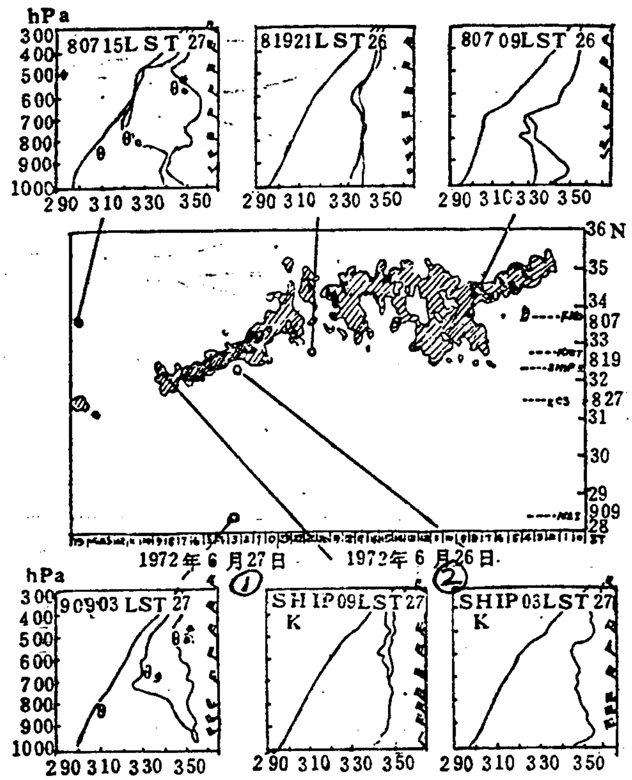

Fig.6 Recurrence Radar Echo Charts and θ, θ_e, and θ_e* Vertical Profile Lines(11) Associated with Survey Stations in the Vicinity for the Period 26-27 June 1972 (1) 27 June 1972 (2) 26 June 1972

Guo Yinghua and Anthes(12) also demonstrated, from medium scale numerical simulations of east asian mei-yu, the differences in nature between the eastern sections and western sections of mei-yu fronts.

IV. SECONDARY SUBSYNOPTIC DISTRUBANCES AND MEI-YU FRONT TORRENTIAL RAINS

1. Brisk and Weak Periods Associated with Mei-Yu Fronts

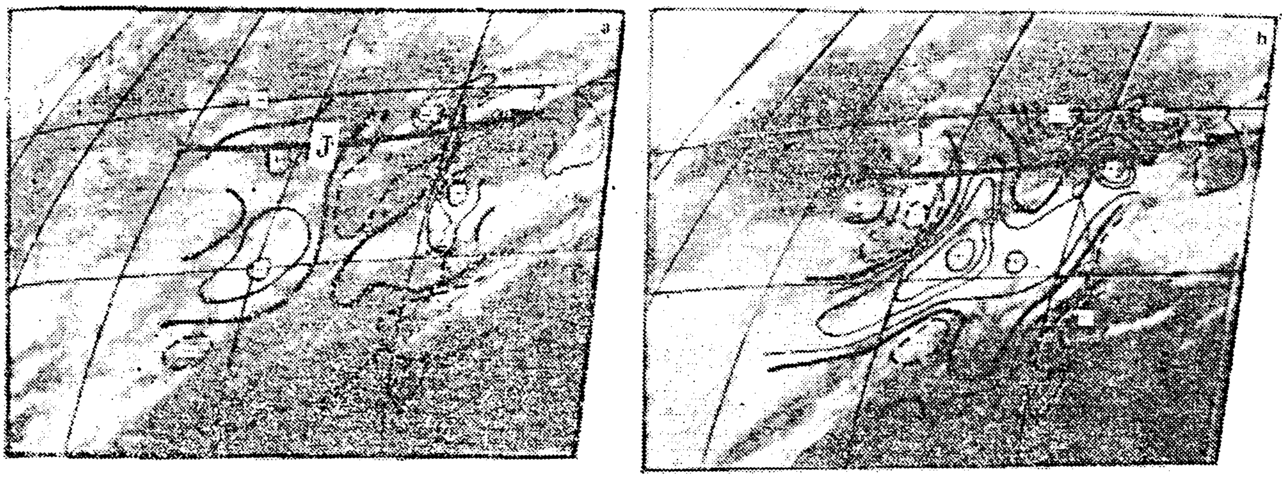

Fig.7 GMS Infrared Cloud Charts and 200hPa Dispersion(13) (a: 26 June 1981 at 20:00 (Beijing Time), b: 27 June 1981 at 08:00 (Beijing Time)). In the Fig.'s, the thick solid lines are diffusion zero lines. Thin solid lines are divergence zones. Thin broken lines are convergence zones. The unit of diffusion is $10^{-5}s^{-1}$. Isopleth intervals are 2 units a line. Thick arrows are high altitude jet stream axses. "J" is a jet stream core.)

During periods of mei-yu front maintenance, there are times when there is one rainbelt along the whole frontal area. In conjunction with this, there are broad scale areas of torrential rains. There are times when mei-yu frontal rainbelts show the occurrence of breaking up. It is only at

particular individual points that there is the occurrence of torrential rains. This represents the two different status types of mei-yu fronts. Fig.7 is GMS infrared cloud charts for 26 June 1981 at 20:00 (Beijing time) and 27 June at 08:00 (Beijing time). Fig.8 is diagrams of the amount of rain every 12 hours from 26 June 1981 at 08:00 - 28 June at 08:00 (Beijing time). In the satellite cloud diagrams for 26 June 1981 at 20:00, mei-yu front cloud belt cloud layers were relatively thin. They were also narrow in width. The mei-yu front rainbelts which correspond to this period of time (Fig.8a,8b) are broken up. Areas of torrential rain are scattered. On 27 June at 08:00, on the satellite cloud charts, mei-yu front cloud belt cloud layers increased in thickness. Cloud belts changed in width. With this, the mei-yu fronts corresponding to the cloud belts had a single line of complete rainbelts (Fig.8c). In conjunction with this, there were fragmented areas of torrential rains.

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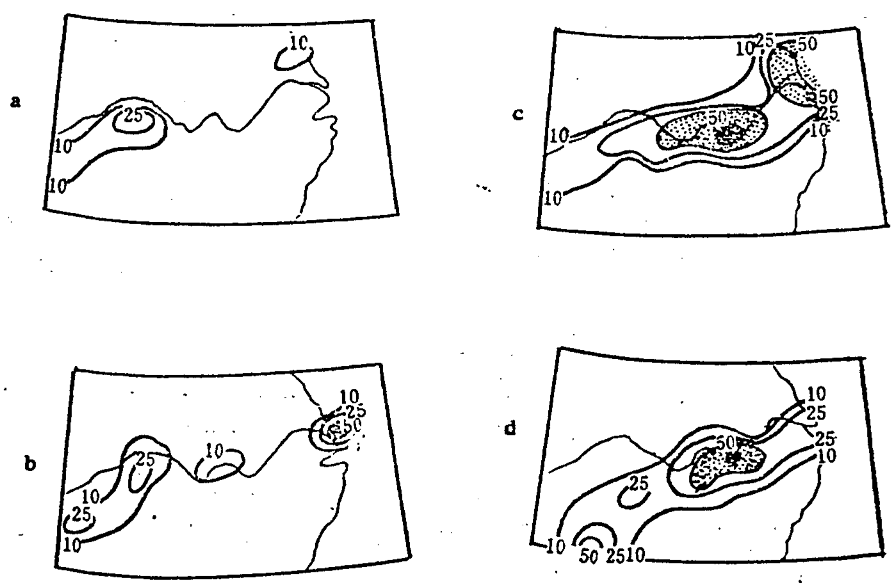

Fig.8 Charts of the Amounts of Rainfall Every 12 Hours from 26 June 1981 at 08:00 - 28 June at 08:00 (Beijing Time)[13] (a: 26 June 08:00-20:00 b: 26 June 20:00-27 June 08:00 c: 27 June 08:00-20:00 d: 27 June 20:00-28 June 08:00. Unit for Amount of Rainfall: mm. Shaded Areas Are Areas of Rain Above 60mm.)

There is an intimate relationship between these two types of mei-yu front states and the existence of upper air diffusion forms. As far as the weak periods of mei-yu fronts are concerned (Fig.7a), the upper part of the 318
troposphere in the middle reaches of the Yangtze valley is a convergence zone. The two sides of the convergence zone are weak divergence zones. Troposphere sinking movements which are related to upper air convergence cause the mei-yu front cloud belts in the zones in question to be relatively weak, even to the point of disappearing. Because of this, the break up of mei-yu front rainbelts is created. With regard to brisk periods in mei-ẏu fronts (Fig.7b), the upper part of the troposphere is a relatively weak divergence zone along the Yangtze valley. Rising troposphere movements related to upper air divergence trigger the release of geopotential instabilities associated with mei-yu front areas. Convection development causes mei-yu front cloudbelts to increase in thickness and change width, with the development of torrential rains. From this, one grasps that there is an intimate relationship between the development of vertical movements associated with mei-yu front areas and the briskness or weakness of mei-yu fronts. Moreover, the vertical movements of mei-yu fronts are also produced through the effects from secondary subsynoptic distrubances on mei-yu fronts. Therefore, the distrubances of secondary subsynoptic systems on mei-yu fronts are causes which lead to briskness in mei-yu fronts and the development of torrential rains.

2. Secondary Subsynoptic Disturbances Which Give Rise to Mei-Yu Front Briskness

There are a number of types of secondary subsynoptic disturbances. At present, the several types of systems below have already been discovered.

(1) Upper Air Jet Stream Centers

In mei-yu periods, the upper part of the east asian troposphere is under the control of south asian high pressure. Secondary tropical west wind jet streams shift north to the vicinity of $40^{O}N$, positioned on the north side of the mei-yu fronts. Under conditions of straight and even west wind circulation, normally one has a movement east of upper air jet stream centers or cores following along the axis of the jet stream. Upper air jet stream centers or cores are one type of secondary subsynoptic wind speed disturbance. A good deal of research(14-15) already demonstrates that upper air jet stream centers on the north side of mei-yu fronts are important secondary subsynoptic systems which produce distrubances in mei-yu fronts in conjunction with which they give rise to lower air jet streams and the development of torrential rains.

The mechanism by which upper air jet stream centers disturb mei-yu fronts is two level circulation forced into existence by non-georotation. Effects of non-georotational winds associated with upper air jet steam centers or cores create divergence zones at the right side of jet stream entry zones and the left side of exit zones. The left side of entry zones and the right side of exit zones are convergence zones(16). Receiving the compelling effects of this high altitude dispersion, in entry zones, there is formed a direct thermal circulation. The rising branch is on the south side of the jet stream axis. The sinking branch is on the north side of the jet stream axis. In exit zones, there is formed an indirect thermodynamic circulation. The rising branch and sinking branch are each on the north and south side of the jet stream axis. Si Gongwang and others(14)

have already pointed out that divergence in the upper troposphere associated with the right side of upper air jet stream entry areas is capable of creating negative pressure changes in the lower portion of the troposphere. From the effects of variable pressure winds, it is possible to give rise to the formation and development of low layer southwest wind jet streams. A good deal of research[15,17] points out that the right rear sides of high air jet stream centers or cores and the left forward edges of low layer jet streams are the development zones associated with mei-yu front torrential rains. Gao Kun and Huang Anli[18] provided actual cases (Fig.9) of the coupling of high and low air jet streams in the east asian mei-yu period causing disturbances in mei-yu fronts and the development of torrential rains. On 23 June 1979 between 08:00-20:00 (Beijing time), upper air jet stream centers or cores shifted to the lower reaches of the Yellow River. Lower air jet streams were positioned on the right side of the entry zone. At this time, one saw the appearance of the occurrence of mei-yu front torrential rains. Between 08:00-20:00 on the 24th, the upper air jet stream center or core in question shifted east into the sea. Torrential rains weakened. At the same time, in the southern part of the Great Bend area of the Yellow River, there was yet another new upper air jet stream center or core moving east. At 08:00 on the 25th, this new jet stream center shifted into the lower reaches of the Yellow River, positioning the right side of its entry zone in the middle and lower reaches of the Yangtze River. In the lower air, there was also the development of a new lower air jet stream. In mei-yu fronts, there was also the appearance of a process of torrential rains.

With regard to the weather process modes or forms of upper air jet stream centers in disturbances of mei-yu fronts,

they are capable of being displayed as shown in Fig.10. In mei-yu periods, west wind belt jet streams are positioned on the north side of mei-yu fronts. When mei-yu fronts are positioned on the lower right side of upper air jet stream center exit zones, upper air convergence gives rise to sinking movements which cause weakening of mei-yu fronts. Mei-yu front rainbelts break up. When upper air jet stream centers move east, the right side of their entry zones is positioned in the upper air of mei-yu fronts. At this time, upper air divergence gives rise to rising movements which lead to mei-yu front briskness, the formation of mei-yu front rain belts, and the development of torrential rains.

2) Westerlies Short Wave Trough

The west wind or westerlies belt small trough which moves east from the north edge of the Tibet plateau is capable of producing disturbances in mei-yu fronts.

Upper air short wave troughs are weak geopotential field disturbances. They are also a vorticity advection system. In the front of short wave troughs, compelling effects associated with upper air positive vorticity advection give rise to the development of rising movements. When the effects of rising movements in front of short wave troughs are in mei-yu fronts, this will give rise to the briskness of mei-yu fronts and the development of torrential rains.

Upper air short wave troughs often, in satellite cloud charts, can show the existence of a cloud ring in front of the trough. The actual development of the weather clearly shows that, when there is overlapping on mei-yu front cloud

belts, there is the development of mei-yu front torrential rains.

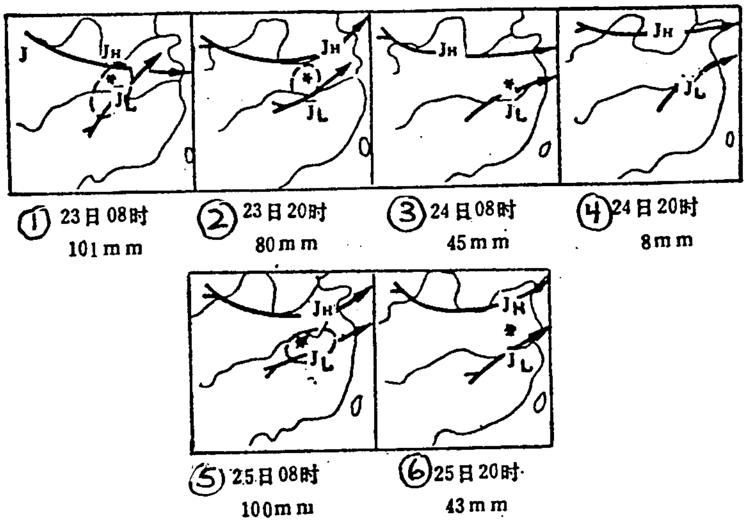

Fig.9 Dynamic Diagrams of Upper and Lower Air Jet Streams and Areas of Torrential Rain from 23-25 June 1979[18] (In the Fig.'s, "J_H" and "J_L" respectively represent high and low air jet stream centers or cores. The broken lines are areas with 12 hour amounts of rainfall greater than 50mm. "*" represents centers of torrential rain. The values for amounts of rainfall are recorded under the diagrams.) (1) 08:00 on the 23d (2) 20:00 on the 23d (3) 08:00 on the 24th (4) 20:00 on the 24th (5) 08:00 on the 25th (6) 20:00 on the 25th.

Weather types associated with mei-yu front disturbances from upper air short wave troughs are as shown in Fig.11. Mei-yu front torrential rain areas are primarily produced in rising air flow troposphere zones and upper air divergence

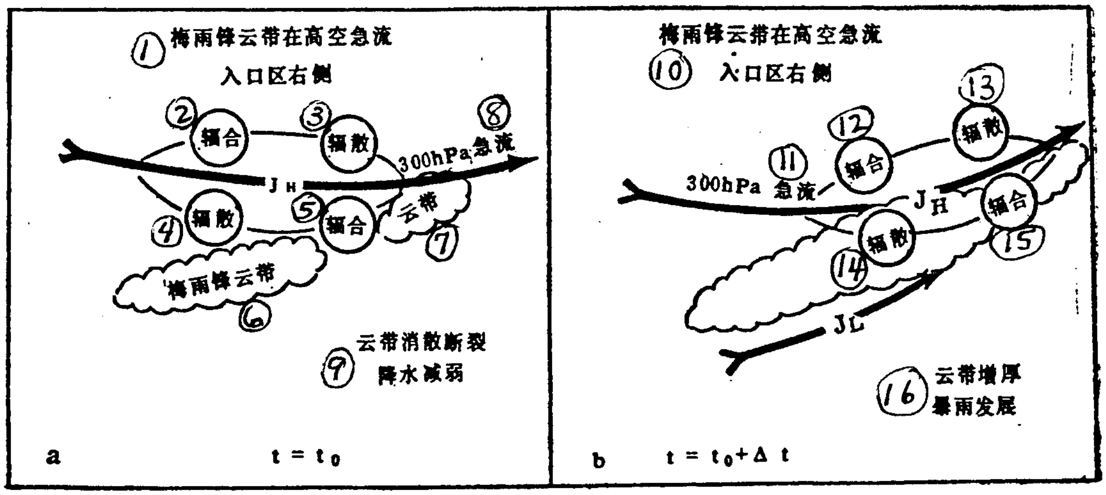

Fig.10 Weather Process Types Associated with Mei-Yu Front Distrubances from Upper Air Jet Stream Centers or Cores (1) Mei-Yu Front Cloudbelts on the Right Side of Upper Air Jet Stream Entry Zones (2) Convergence (3) Divergence (4) Divergence (5) Convergence (6) Mei-Yu Front Cloudbelt (7) Cloudbelt (8) Jet Stream (9) Cloudbelts Disperse and Break Up. Precipitation Weakens. (10) Mei-Yu Front Cloudbelts on the Right Side of Upper Air Jet Stream Entry Zones (11) Jet Stream (12) Convergence (13) Divergence (14) Divergence (15) Convergence (16) Cloudbelt Thickness Increases. Torrential Rains Develop.

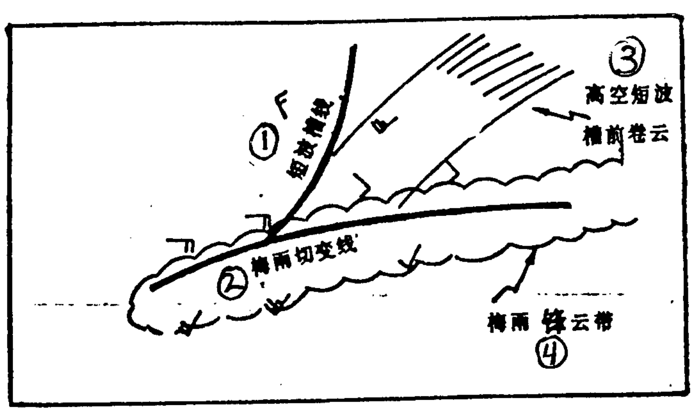

Fig.11 Weather Types Associated with Mei-Yu Front

Distrurbances from Upper Air Short Wave Troughs (1) Short Wave Trough Line (2) Mei-Yu Shear Line (3) Cloud Ring in Front of Upper Air Short Wave Trough (4) Mei-Yu Front Cloudbelt

in front of troughs. At times when upper air short wave troughs are relatively weak, and, in conjunction with that, their primary movement is east, the tail ends of trough lines will merge with mei-yu front shear lines. Mei-yu front cloud belts will hold their original positions. The nature of the west ends of mei-yu fronts is not effected. When cold air is relatively strong, upper air short wave troughs develop toward the south. This is showing the nature of a cold front which is capable of pushing mei-yu front cloud bands toward the south. At the same time, mei-yu fronts are changed to possess relatively strong baroclinic natures. This type of process is capable of explaining the kind of phenomena where mei-yu fronts sometimes do not possess the nature of frontal surfaces and sometimes change to possess the nature of frontal surfaces[19].

(3) Southwest Vortex

Southwest vortices are intermediate scale α vortices produced by the leeward slopes of the Tibet plateau. The vortices are produced on an 850-700hPa isobaric surface. At ground level and above 500hPa, by contrast, they are not noticable.

The processes associated with the production of southwest vortices fall into a number of types[20]. After the formation of southwest vortices, at times when there are no influences from short wave troughs, vortices stop and stagnate with rare movements. However, at times when there are influecnes from upper air short wave troughs, vortices are capable, under traction associated with short wave troughs, of moving east along mei-yu front shear lines. Because of this, southwest vortices themselves are an intermediate scale α disturbance positioned on plum rain (mei-yu) shear lines. The weather process form associated

with the eastern movement of southwest vortices is as shown in Fig.12. At times when short wave trough lines invade southwest vortices, rear portions of low vortices show the appearance of cold advection. This will cause the low vortices to move east along shear lines. Sometimes, this forms what forecasters call a "north trough south vortex" configuration.

In situations where there are southwest vortices, the rising movements associated with mei-yu front zones are capable of containing several types of dynamic compelling effects: (1) Rising movements associated with positive voritcal advection compelling in front of short wave troughs. (2) Rising movements which are forced by southwest vortices themselves. These are rising movements which are given rise to in the troposphere by air flow convergence produced in the cores of low vortices at times when the flow field wind speeds associated with southwest vortices are larger than geo-rotational wind wind speeds. Huang Fujun's[21] synthetic or formation analysis of southwest low vortices yields that the synthesis of low vortical centers or cores below 500hPa is cyclonic vorticity and convergence zones. At 200hPa, it is anticyclonic vorticity and divergence zones. Its results clearly show the dynamic compelling effects associated with low vortices themselves. (3) Rising movements compelled by non-georotational dynamics and associated with low air jet steams on the south side of low vorticies. Dynamic compelling associated with low air jet streams is dynamic compelling associated with low vortices themselves and are mutually independent dynamic effects. Fig.13 is a two level circulation diagram of the synthesis or formation of southwest vorticies in south China pre-flood periods. In the centers or cores of vorticies, there is a branch of rising air flow. This is a rising movement compelled by the vortex itself. Besides this, at a

place 300 km south of vortex centers or cores, there is also a branch of rising air flow. This represents rising air flow compelled by low air jet streams.

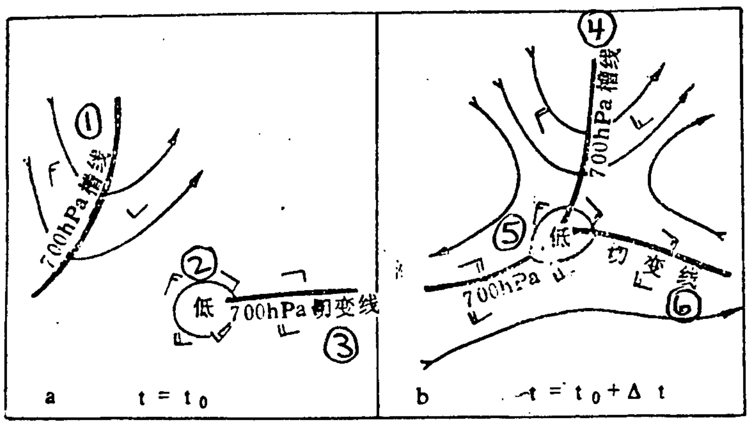

Fig.12 Weather Process Forms Associated with the Eastward Movement of Southwest Vortices Along Mei-Yu Shear Lines (1) Trough Line (2) Low (3) Shear Line (4) Trough Line (5) Low (6) Shear Line

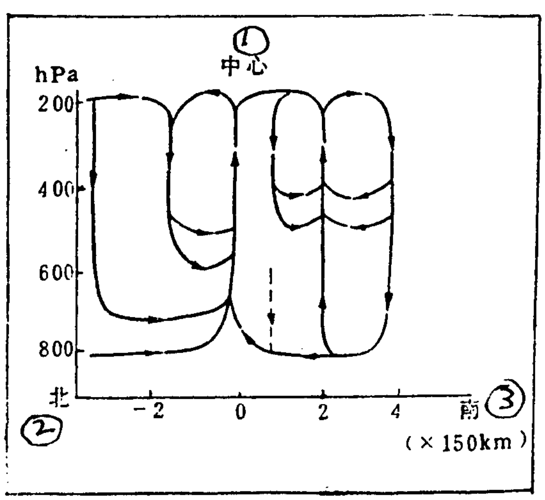

Fig.13 Two Level Circulation Diagram[22] for the Formation of Southwest Vorticies in the South China Pre-Flood Period (1) Center (2) North (3) South

In southwest vortex situations, there are times when these dynamic compelling effects are capable of concentrating together. This will create an even stronger degree of briskness in mei-yu fronts, forming severe torrential rain weather.

(4) Intermediate Scale Cyclones

Cyclones with a scale of 1000-3000 km are designated intermediate scale cyclones. The difference between these and weather scale or subsynoptic cyclones is that the latter --in the upper troposphere--have mutual upper air trough matching. But, the former--at 500 hPa--are straight and level westerly wind circulations. The kinetic energy of cyclonic disturbances is only limited to below 500 hPa. In the upper troposphere, by contrast, there is a warm center and high pressure ridge. The differences between the two structures clearly show that there are differences between the dynamic effects which form the two types of cyclones and the mechanisms. The mechanism associated with the production of weather scale or subsynoptic cyclones is baroclinic instability. However, the mechanism associated with the production of intermediate scale cyclones is CISK. The development and disturbance weather processes impacting mei-yu fronts are as shown in Fig.14. The dynamic causative factors associated with the beginning of this type of cyclone originate with the warm air in the low layers of the atmosphere(23). The warm lower layer advection in question increases in strength causing the air pressure in mei-yu fronts to drop and produce weak convergence and rising of low layer air flows. Convergence rising leads to the release of geopotential instabilities and convection development. Release of latent heat caused by convection makes for the development of mei-yu front low pressure. Low

pressure development also--one step further--stimulates additional convection from water vapor supplies and in rising movements. From this process is created briskness of mei-yu fronts and the development of torrential rains. Si Gongwang(24), from diagnostics, also got the key dynamic causative factors associated with the period of the production of Yangtze-Huai cyclones to be the effects of latent heat. Chen Jiabin(25) has already used numerical model simulations on this type of development process.

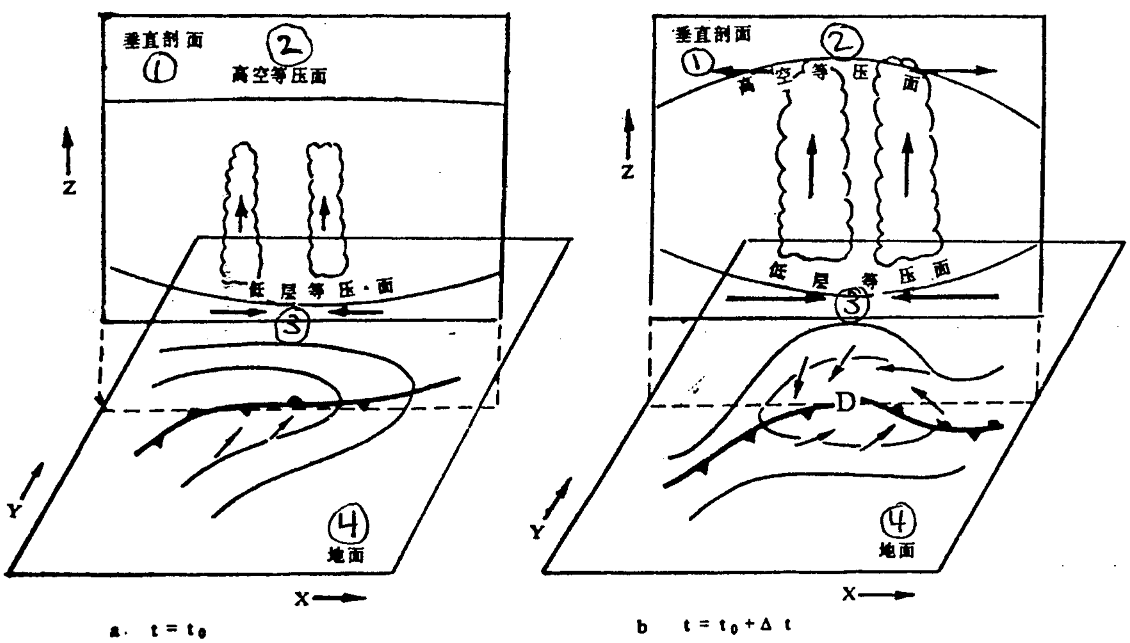

Fig.14 Weather Process Types Associated with the Development of Intermedite Dimension Cyclones (1) Vertical Cross Section (2) Upper Air Isobaric Surface (3) Low Layer Isobaric Surface (4) Ground Surface

When intermediate dimension cyclones and upper air west wind troughs combine with each other, they then develop the baroclinic natures of weather dimension or subsynoptic cyclones.

Ninomiya and others[26] pointed out that torrential rains during the mei-yu period in Japan are primarily produced by intermediate and weather dimension or subsynoptic cyclones.

3. The Effects of Secondary Subsynoptic Disturbances on Mei-Yu Front Torrential Rains

Briskness of mei-yu fronts and the development of torrential rains are related to subsynoptic disturbances. From the intermediate scale numerical value simulations of Guo Yinghua and Anthes[12] as well as Li Yufang[27] and others, for mei-yu (plum rains), it was discovered that the primary dynamic causative factors associated with the development of torrential rains are the dynamic effects of latent heat. The experiments of Guo Yinghua and Anthes[12] pointed out that, in middle dimension forms, including the effects of latent heat and removing the effects of latent heat (The latter still had the occurence of water vapor condensation. It was only the dynamic effects of latent heat that were taken out.), the two types of predicted sea surface air pressure fields and low level temperature fields were almost completely the same. However, predictions without the effects of latent heat had predicted amounts of precipitation which were very, very greatly reduced. It is clearly shown from this that, taking 322
out the effects of latent heat, mei-yu fronts are only weakened and certainly do not disappear. This adequately explains why secondary subsynoptic systems, in their disturbances of mei-yu fronts, only give rise to the effects

of a type of triggering mechanism in the development of torrential rains. The rising movements which are caused by their dynamic compelling effects cause mei-yu front zones to be released from geopotential instabilities formed by advection. Therefore, this leads to mei-yu front briskness and the development of torrential rains. However, the primary dynamic causative factor in the development of torrential rains, by contrast, is the feedback effects of latent heat.

V. CONCLUSIONS

This article discussed the large scale circulations of east asian mei-yu fronts, the special characteristics of mei-yu fronts, the briskness or liveliness of mei-yu fronts, and the occurrence of torrential rainfall. In conjunction with that, it presented a number of conceptual models or types. The primary conclusions were as follows:

1. East asian mei-yu phenomena are ones produced in a transition belt between the Indian southwest monsoon system and the north Pacific Hadley (or trade wind) system. In this transiton belt, the Indian monsoon trough and the north Pacific ITCZ develop discontinuities. The Indian southwest monsoon winds and southern hemisphere tropical air flows across the equator at 110^{o}E penetrate deeply along west Pacific subtropical high pressure into the eastern part of the Chinese mainland. In conjunction with this, in the vicinity of 30^{o}N, there is a direct confluence with polar cold air masses to form mei-yu fronts. From this is formed the east asian subtropical humid zone.

2. Mei-yu fronts are confluence zones between tropical air masses and polar cold air masses. They have a

semi-tropical, semi-temperate nature as weather systems. In mei-yu front zones, the troposphere has differential corresponding location temperature advections, forming an atmospheric layer of geopotential instability. The release of geopotential instability leads to phenomena of strong precipitation in mei-yu fronts and neutral atmospheric layer structures.

The release of mei-yu front area geopotential instabilities occurs through secondary subsynoptic system disturbances of mei-yu fronts. Rising movements compelled by secondary weather scale or subsynoptic systems lead to the release of geopotential instabilities and the development of convection. This gives rise to briskness in mei-yu fronts and the development of torrential rains. Secondary subsynoptic systems which disturb mei-yu fronts include upper air jet stream centers, upper air west wind short wave troughs, southwest vortices and intermediate scale or mesoscale cyclones, etc. Secondary subsynoptic disturbances are trigger mechanisms for the development of torrential rains. However, dynamic effects associated with latent heat feedback are the principal dynamic causative factors in the development of torrential rains.

The various types of characteristics of east asian mei-yu fronts, which are summarized above, still need further study. We believe that advances a step deeper into studies of observation, diagnosis and numerical value simulations will make our knowledge of east asian mei-yu systems even deeper, and will make us grasp even better the climatic and weather patterns of China and East Asia in order to make a contribution to the economic development of the nation.

REFERENCES

[1] Riehl, H., Climate and weather in the tropics, Academic Press, 1979.

[2] 陈秋士、缪锦海、李维亮,1958年7月亚洲东南部西南季风区和太平洋信风区平均流场和平均经圈环流,气象学报,34,1,51-61,1964。

[3] Newell, R. E. et al., The general circulation of the tropical atmosphere and its interaction with extratropical latitudes, Mass. Inst. Tech. Press, Cambridge, Mass.,1974.

[4] Krishnamurti, T. N., and Y. Ramanathan, Sensitivity experiments on the monsoon onsect to differential heating, *J. Atmos. Sci.*, 39, 1290-1306, 1982.

[5] 陶诗言、何诗秀、杨祖芳, 1979年季风试验期间东亚地区夏季风爆发时期的观测研究, 大气科学, 7,4, 347-355, 1983。

[6] 孙淑清, 东亚大尺度低空急流的背景场与东半球的越赤道气流, 气象学报, 44,1,55-62,1986。

[7] 王继志、李麦村, 源于澳洲过赤道气流与中国季风环流和降水, 大气科学, 6,1,1-9,1982。

[8] 陶诗言、赵煜佳、陈晓敏, 东亚的梅雨与亚洲上空大气环流季节变化的关系, 气象学报,29,119-134,1958。

[9] 叶笃正、陶诗言、李麦村, 在六月和十月大气环流的突变现象, 气象学报, 29,249-263,1958。

[10] Ninomiya, K., Characteristics of Baiu front as a predominant subtropical front in the summer Northern Hemisphere, *J. Meteor. Soc. Japan*, 62,6,880-894,1984.

[11] Ninomiya, K., and K. Yamazaki, Heavy rainfalls associated with frontal depression in Asian subtropical humid region, (II) Mesoscale features of precipitation, *J. Meteor. Soc. Japan*, 57,5, 399-413,1979.

[12] Kuo, Y.H. (郭英华), and R. A. Anthes, Numerical simulation of a Mei-Yu system over southern Asia, Papers in Meteorological Research, 5,15-35,1982.

[13] 斯公望、杜立群,南亚高压北缘的高空气流发散与梅雨暴雨发展的关系,杭州大学学报,14,2,233-244,1987。

[14] 斯公望、俞樟孝、李法然、杨厥正, 一次梅雨锋低空急流形成的分析, 大气科学, 6,2,165-170,1982。

[15] 黄安丽、高坤, 对流层高低空急流耦合作用的动力学分析, 杭州大学学报, 9,3,356-364,1982。

[16] Uccellini, L., and D. R. Johnson, The coupling of upper and lower tropospheric jet streak and implications for the development of severe convective storm, *Mon. Wea. Rev.*, 107 6, 682-703, 1979.

[17] 肖文俊等, 高空和低空急流和暴雨的关系的天气分析, 大气科学, 8, 83-88, 1984。

[18] 高 坤、黄安丽, 低空急流暴雨系统的湿斜压诊断分析, 杭州大学学报, 11, 369-380, 1984。

[19] 王德瀚、韦统健, 伴有特大暴雨的梅雨锋结构特征, 长江流域暴雨文集, 176-181, 气象出版社, 1982。

[20] 包澄澜、李生辰, 西南涡成因初探, 气象, 11,1,2-6,1985。

[21] 黄福均, 西南低涡的合成分析, 大气科学, 10,4,402-408,1986。

[22] 柳崇健、赵深铭, 华南前汛期合成低涡风场的结构特征, 大气科学, 9,205-210,1985。

[23] Chen, T. C., C. B. Chang and D. J. Perkey, Synoptic study of a mediumscale oceanic cyclone during AMTEX'75, *Mon. Wea. Rev.*, 113,439-361,1985。

[24] 斯公望, 一次江淮气旋发生发展动力因素的计算分析, 大气科学, (2),6-17,1976。

[25] 陈嘉滨、季仲贞、朱抱真, 一次降水气旋生成的数值模拟, 暴雨文集, 94-102,吉林人民出版社, 1980。

[26] Ninomiya, K., and T. Akiyama, Medium-scale echo clusters in the Baiu front as revealed by multi-radar composite echo maps, *J. Meteor. Soc. Japan*, 50,558-569,1972。

[27] 李毓芳、黄安丽、高坤, 对流加热在暴雨系统中的作用, 中国科学B辑7月号,765-775,1986。

Key on following page.

(2) Chen Qiushi, Miao Jinhai, Li Weiliang; "Average Flow Fields and Average Longitudinal Ring Circulations in the Southwest Monsoon Area and the Pacific Trade Winds Area of Eastern Asia in July, 1958", ACTA METEOROLOGICA SINICA, 34,1,51-61,1964.

(5) Tao Shiyan, He Shixiu, Yang Zufang; "Observational Study of the Period of the Onset of the Summer Monsoon in the East Asia Area in the Monsoon Experimentation Period of 1979", Atmospheric Science, 7,4,347-355,1983.

(6) Sun Shuqing; "Background Fields and Eastern Hemisphere Cross-Equatorial Air Flows Associated with East Asian Macroscale Low Air Jet Streams", ACTA METEOROLOGIA SINICA, 6,1,1-9,1982.

(7) Wang Jizhi, Li Maicun; "Cross-Equatorial Air Flows Originating in Australia and Chinese Monsoon Circulation and Precipitation", Atmospheric Science, 6,1,1-9,1982.

(8) Tao Shiyan, Zhao Yujia, Chen Xiaomin; "The Relationships Between East Asian Plum Rains and Seasonal Changes in Asian Upper Air Atmospheric Circulation", ACTA METEOROLOGICA SINICA, 29,119-134,1958.

(9) Ye Duzheng, Tao Yanshi, Li Maicun; "Mutation Phenomena in June and October Atmospheric Circulation", ACTA METEOROLOGICA SINICA, 29,249-263,1958.

323

(13) Si Gongwang, Du Liqun, "The Relationship Between Upper Air Flow Divergence on the North Edge of Asian High Pressure and the Development of Mei-Yu Torrential Rains", Hangzhou University Journal, 14,2,233-244,1987

(14) Si Gongwang, Yu Zhangxiao, Li Faran, Yang Juezheng; " An Analysis of One Occurrence of Mei-Yu Front Low Air Jet Stream Formation", Atmospheric Science, 6,2,165-170,1982.

(15) Huang Anli, Gao Kun; "A Dynamics Analysis of the Coupling Effects of Troposphere Upper and Lower Air Jet Streams", Hangzhou University Journal, 9,3,356-364, 1982.

(17) Xiao Wenjun, et.al.; "Weather Analysis of Relationships Between Upper Air and Lower Air Jet Streams and Torrential Rains", Atmospheric Science,8,83-88,1984.

(18) Gao Kun, Huang Anli; "Humid Baroclinic Diagnostic Analysis of Lower Air Jet Stream Torrential Rain Systems", Hangzhou University Journal, 11,369-380,1984.

(19) Wang Dehan, Wei Tongjian; "Mei-Yu Front Structural Characteristics Accompanied by Particularly Large Torrential Rains", Yangtze Valley Torrential Rains Collection, 176-181, Meteorology Press, 1982

(20) Bao Chenglan, Li Shengchen; "An Initial Probe into the Reasons for the Formation of Southwest Vorticies", Meteorology, 11,1,2-6,1985.

(21) Huang Fujun; " An Analysis of the Formation of Southwest Low Vorticies", Atmospheric Science, 10,4,402-408,1986.

(22) Liu Chongjian, Zhao Shenming; "Structural Characteristics of the Formation of Low Vortex Wind Fields in the South China Pre-Flood Period", Atmospheric Science, 9,205-210,1985.

(24) Si Gongwang; "A Calculation Analysis of Dynamic Causative Factors in One Occurrence of the Production and Development of Yangtze-Huai Cyclones", Atmospheric Science, (2),6-17,1976.

(25) Chen Jiabin, Li Zhongzhen, Zhu Bao(unclear)zhen; "Numerical Simulation of the Formation of One Precipitation Cyclone", Torrential Rains Collection, 94-102, Jilin Peoples Press, 1980.

(27) Li Yufang, Huang Anli, Gao Kun; "The Effects of Convection Heating in Torrential Rain Systems", Chinese Science Ed.B, July No., 765-775,1986.

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